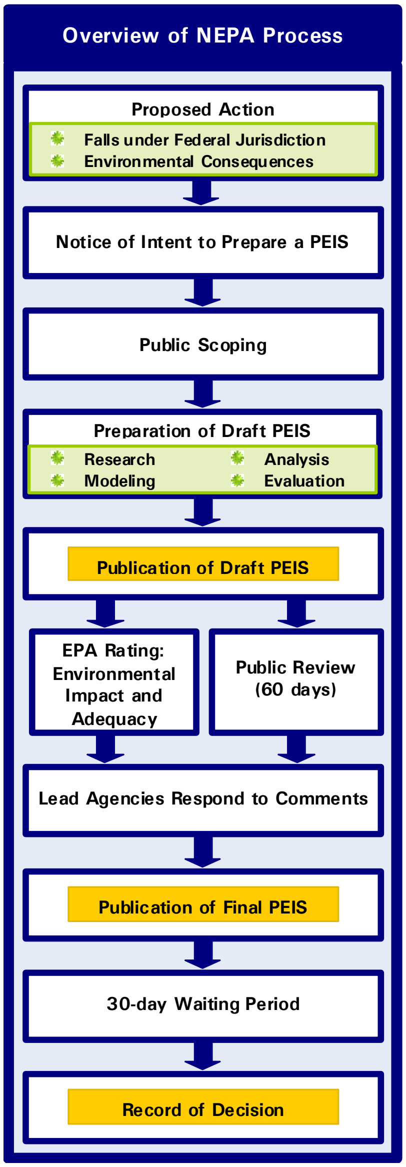
1 Purpose and Need For Action

1.1 STUDY AUTHORITY, SCOPE, AND STATEMENT OF PURPOSE

1.1.1 Authority and Scope for a Programmatic Environmental Impact Statement

Oysters once contributed significantly to maintaining water quality and habitats in the Chesapeake Bay ecosystem, supported an economically important fishery, and were of great cultural value to many residents of the Bay area. The population of the native Eastern oyster (*Crassostrea virginica*) has declined to a small fraction of its historical abundance, and restoration efforts undertaken to date have failed to reverse the decline (Sections 1.2 and 1.3). Recognizing this failure, the States of Maryland and Virginia have begun to consider nontraditional approaches for attempting to rebuild the oyster stock, including introducing the nonnative Suminoe oyster (Section 1.4).



The proposal to introduce the Suminoe oyster into Chesapeake Bay is very controversial and has attracted many opponents as well as proponents. All parties concerned about the status of the Bay's oyster stock agreed that the proposal merited a high level of review by agencies responsible for managing natural resources and the environment because of its potentially significant benefits and adverse effects throughout Chesapeake Bay and possibly within other coastal estuaries. Given the need for a rigorous formal evaluation of the potential risks and benefits of the proposed action, the States of Maryland and Virginia requested assistance from the U.S. Army Corps of Engineers (USACE), Norfolk District (CENAO), to develop a Programmatic Environmental Impact Statement (PEIS) to evaluate the proposed introduction of the Suminoe oyster and reasonable alternative strategies for restoring the ecological and economic functions of oysters in Chesapeake Bay. In 2003, Congress authorized CENAO to coordinate the preparation of this PEIS pursuant to the National Environmental Policy Act (NEPA) Section 102. A Notice of Intent to prepare a PEIS was published in the Federal Register in 2004 (FR Vol. 69 No. 2, January 5, 2004). USACE's Baltimore District (CENAB) provided technical support, and the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service (FWS), and the National Oceanic and Atmospheric Administration (NOAA) are cooperating Federal agencies.

The proposal to introduce a reproducing population of Suminoe oysters into Chesapeake Bay is addressed throughout this Draft PEIS as the "proposed action" because that is the NEPA term for the issue that triggers a NEPA evaluation. NEPA requires an environmental impact statement to identify and evaluate reasonable alternatives that are designed to meet the same need that prompted the proposed action and the stated objective of that action. The alternatives are intended to provide a rational context for evaluating the pros and cons of the proposed action and identifying the most appropriate strategy for meeting the stated objective. If the results of analyses presented in this Draft PEIS lead the participating agencies to determine that the proposed action or one of the alternatives is the most appropriate strategy, it would become the "preferred alternative" in NEPA terms. The USACE and the States of Maryland and Virginia have agreed that this Draft PEIS will not establish a preferred alternative so that public comments on the Draft can be considered in selecting a preferred alternative to be identified and supported in the Final PEIS. Details of the proposed action and all alternatives defined for evaluation in this Draft PEIS are presented in Section 2.

A Programmatic EIS, as described in the Council on Environmental Quality's (CEQ) *Forty Most Asked Questions* (CEQ 1981), is used when subsequent NEPA analyses and documents may be prepared in tiers (40 C.F.R. § 1508.28) as narrower, more site-specific plans for implementing the proposed action or an alternative are defined. A PEIS considers multiple related Federal actions that encompass a large geographic scale or that constitute a suite of similar programs, both of which are characteristics of the joint State and Federal effort to restore the size and functions of the oyster population throughout Chesapeake Bay. This PEIS is intended to be used as guidance for subsequent NEPA analyses and decisions that may be needed when more site-specific plans for implementing the proposed action or an alternative are defined. The role of the PEIS is to address broad issues so that the large-scale analyses can be incorporated into subsequent site-specific assessments. A PEIS should support program-level decisions regarding which specific projects will be considered in the future.

The scope of this PEIS is to evaluate the potential effects of the proposed action and each alternative on the resources and ecosystem of the Bay in as much detail as is possible given uncertainties about how the actions, which are described very generally (Section 2), might be implemented. Representative plans for implementing the proposed action and alternatives were developed to provide a basis for predicting and assessing the potential consequences of those actions. Specific implementation plans for any related action undertaken following completion of this PEIS process, however, would almost certainly vary from those assessment scenarios and may require further NEPA analyses and regulatory compliance, as defined in Section 1.1.3. The programmatic analyses presented in this Draft PEIS are based on the best information available at the time the analyses were completed. If new data or information becomes available in the future, that information will be incorporated into later tiers of NEPA analyses to modify the programmatic conclusions as needed. This PEIS has served the important purpose of facilitating collaboration among Federal, State, and local agencies that will be involved in oyster restoration efforts. The interactions among agencies and with the public established by this programmatic

NEPA process will be maintained through the tiered NEPA analyses to ensure comprehensive stakeholder involvement (as recommended by NEPA Task Force 2003).

CENAO is the lead Federal agency for preparing this PEIS. Virginia Marine Resources Commission (VMRC), on behalf of the Commonwealth of Virginia, and Maryland Department of Natural Resources (DNR), on behalf of the State of Maryland, are the lead State agencies. These three entities are referred to throughout this PEIS collectively as the "lead agencies." EPA, FWS, and NOAA are cooperating Federal agencies. Additional review and assistance in preparation of the PEIS was provided by CENAB, the Potomac River Fisheries Commission (PRFC), and the Atlantic States Marine Fisheries Commission (ASMFC). The lead agencies established a project delivery team (PDT) to coordinate with State, Federal and regional agencies whose goals, objectives, policies, and regulations are implicated in or would be affected by the outcome of the project. The PDT includes CENAO, CENAB, DNR, VMRC, EPA, NOAA, FWS, and PRFC. This document was prepared in accordance with Code of Federal Regulations 40, parts 1500 – 1508, CEQ regulation 1502, and Army Regulation 200-2.

1.1.2 Purpose and Need for Action

NEPA requires the preparers of an EIS to develop specific definitions of the need and purpose for action so that reasonable alternatives can be formulated for analysis and evaluation. The lead agencies, working closely with the cooperating agencies via the PDT and with the public via NEPA's scoping process (Section 5), established the following statement of need for the actions being evaluated in this PEIS:

> ***A need exists to restore the ecological role of oysters in the Bay and the economic benefits of a commercial fishery through native oyster restoration and/or an ecologically compatible nonnative oyster species that would restore these lost functions.***

NEPA requires detailed specification of the purpose (i.e., goal) of actions evaluated in an EIS to ensure objective and consistent evaluation of the proposed action in comparison to all alternatives. In its *Chesapeake 2000* agreement, the Chesapeake Bay Program (CBP) established a relatively short-term goal to increase oyster abundance by a factor of 10 above the 1994 level by the year 2010 (Section 1.3). The PDT chose to establish a more expansive goal for the actions being evaluated in this PEIS to reflect the large-scale, programmatic context of the decisions to be based on these analyses. Upon considering the history of oyster harvest in the Bay (Figure 1-1), the PDT observed that harvests remained fairly stable between 1920 and 1970, during a time of significant environmental change within the Bay. The average annual harvest over that period was on the order of 35 million pounds, which is roughly equivalent to five million bushels of market-size oysters (Section 2.1.1). The PDT reasoned that consistent harvests over five decades suggested that the oyster population at that time was large enough and healthy enough to sustain an annual harvest of that volume despite environmental stresses on the Bay's ecosystem; consequently, a population of that size probably provided substantial ecological services in the Bay and would be an appropriate, albeit ambitious, goal for restored oyster abundance.

The PDT, in cooperation with the public, therefore, defined the following statement of purpose for the actions being evaluated in this PEIS:

> ***The purpose of this proposal is to establish an oyster population that reaches a level of abundance in Chesapeake Bay that would support sustainable harvests comparable to harvest levels during the period 1920–1970.***

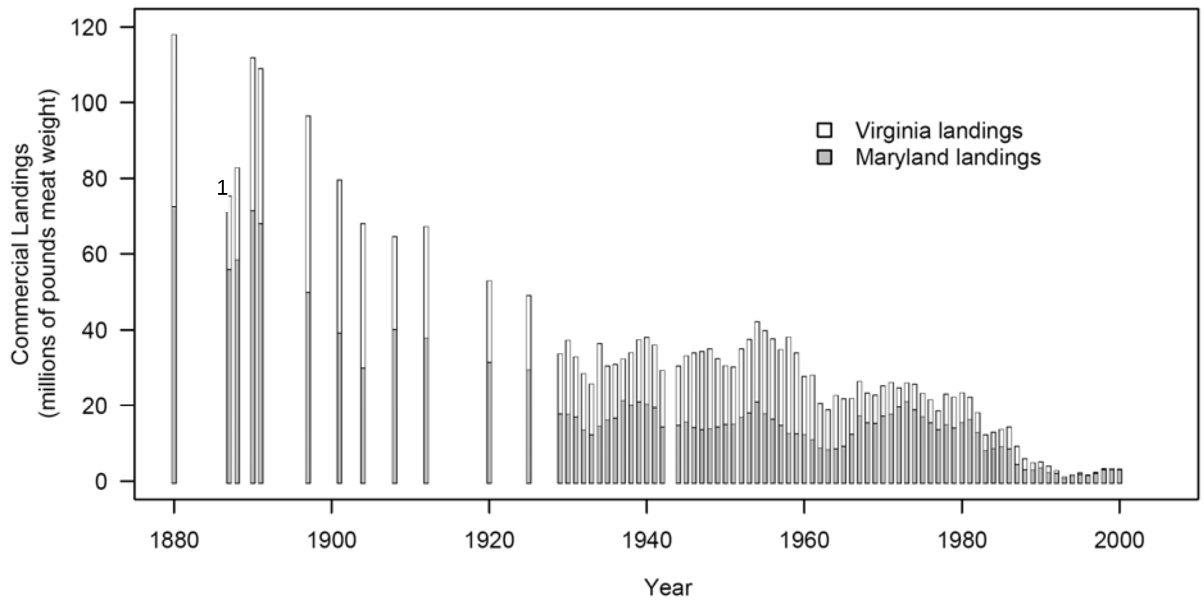


Figure 1-1. Commercial landings of oysters in Chesapeake Bay from 1880 to 2005. Adapted from NRC (2004) with data provided by NOAA. No data are available for years with no bars. The year 1887 (indicated by "1" on the graph) excludes catch from the James and Potomac rivers.[1]

The views of many stakeholders and agencies differ regarding the relative importance of the ecological functions of oysters and the socioeconomic contributions of an oyster fishery in Chesapeake Bay. The PDT intends the statement of purpose to address both of these important considerations, as specified in the statement of need. The PDT intends the term "sustainable harvests" to comprise both harvests of wild oysters and landings of cultivated oysters from leased bottom and other forms of aquaculture throughout the Bay. The stated purpose addresses the need for action to restore the abundance of oysters Bay-wide, without differentiating between Maryland and Virginia. The PDT did not consider the feasibility of achieving a population of the size implied by the statement of purpose when they developed it. They intended the analyses for the PEIS to determine the extent to which the proposed action and the alternatives might be capable of reaching the implied goal. Section 2 provides more information about how this statement of purpose was interpreted to evaluate the proposed action and alternatives.

[1] Commercial landings of oysters are reported in pounds of oyster meat after the oysters are shucked; 7 pounds of oyster meat is considered the equivalent of 1 bushel of market-size (more than 3 inches long) oysters.

1.1.3 Regulatory Compliance[2]

If DNR and VMRC choose to implement a Bay-wide oyster restoration program based on the outcome of this PEIS, the projects designed to implement the preferred alternative could be required to comply with several Federal regulations. The implementation details of a specific restoration program designed following completion of the PEIS process will determine which Federal regulations apply to the program. NEPA requires the preparers of a PEIS to identify the potentially applicable regulations at the beginning of the process because those regulations help to define which elements of the natural and human environments must be evaluated and identify the required consultations with other Federal agencies that have regulatory authority for components of the potentially affected environment. The following suite of potentially applicable regulations served as the basis for identifying topics addressed in Section 3, Affected Environment, and analyzed in Section 4, Environmental Consequences, of this Draft PEIS:

- **Endangered Species Act of 1973**, as amended (Pub. L. 93-205; 16 U.S.C. 1532 et seq.) – requires an evaluation of the potential consequences of the program for Federally listed species within the project area, and completion of Section 7 consultations with the FWS and NOAA's National Marine Fisheries Service (NMFS) as needed.

- **Magnuson-Stevens Fishery Conservation and Management Act**, as amended (Pub. L. 94-265; 16 U.S.C. 1801, et seq.) – requires evaluation of the potential consequences of the program for designated essential fish habitat for Federally managed species in the project area; NMFS reviews such evaluations.

- **National Historic Preservation Act of 1966**, as amended (Pub. L. 89-655; 16 U.S.C. 470. et seq.) – requires evaluation of the potential consequences of the program for historical and archeological resources in the project area; requires consultation with the appropriate State Historical Preservation Office(s) to ensure that cultural resources are identified and to obtain a formal opinion regarding potential loss or damage of important resources or to develop a Memorandum of Agreement about appropriate management or mitigation for any affected resources.

- **Fish and Wildlife Coordination Act of 1958**, as amended (Pub. L. 85-624; 16 U.S.C., et seq.) – requires equal consideration for fish and wildlife resources in conjunction with water resources development programs and projects. It provides authority for the involvement of FWS and NMFS in evaluating potential effects on fish and wildlife and requires Federal agencies that construct, license, or permit water resource development projects to first consult with the FWS or NMFS, as appropriate, regarding the potential effects on fish and wildlife resources and measures to mitigate these effects.

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[2] The descriptions of potentially applicable regulations are provided as a summary for the convenience of the reader. These descriptions are not complete statements of applicable law nor do they define the full requirements of any regulatory program. These descriptions should not be considered legal advice. For legal requirements, the reader is referred to the relevant statutes, regulations, executive orders, and other program documents.

- **Coastal Zone Management Act of 1972**, as amended (Pub. L. 92-583; 16 U.S.C. 1451, et seq.) – requires a Federal activity or program that may affect coastal areas to be consistent with applicable Coastal Zone Management (CZM) Plans and to receive a consistency determination from the applicable State CZM program(s) prior to taking action.

- **Clean Water Act of 1977**, as amended (Pub. L. 92-500; 33 U.S.C. 1251, et seq.) – Under Section 402, National Pollutant Discharge Elimination System permits could be required for stormwater discharges from, and sediment and erosion control at, construction sites (e.g., new hatcheries) or for other actions that might affect water quality (e.g., large-scale aquaculture operations). EPA has not determined if Section 402 applies to "discharges" of nonnative species into the waters of the United States. Further consultation with EPA Region 3 will be necessary if the proposed action is selected as the preferred alternative. Depending on the nature of the preferred alternative and the specific implementation plans for that alternative, Maryland, Virginia, or both may have to apply to USACE for permits under Section 404, which regulates the discharge of dredged or fill material into waters of the United States.

- **Non-indigenous Aquatic Nuisance Prevention and Control Act of 1990**, as amended (16 U.S.C. 4701 et seq.); Lacey Act, as amended (18 U.S.C. 42); 1993 Chesapeake Bay Policy for the Introduction of Non-Indigenous Aquatic Species and applicable and appropriate Executive Orders – include a range of requirements and assessments prior to the introduction of nonnative species.

- **Rivers and Harbors Act, Section 10** – requires permits from USACE for any work in, over, or under navigable waters of the United States.

- **Marine Protection, Research, and Sanctuaries Act Of 1972** – requires a permit from EPA to transport material from anywhere for the purpose of ocean dumping by United States agencies or United States-flagged vessels or for dumping of material transported from outside the United States into the United States territorial sea; USACE is the permitting authority for dredged material, subject to EPA concurrence and use of EPA dumping criteria and EPA-designated dumping sites.

Several other laws, executive orders, and agreements might be applicable to alternatives that involve the Suminoe oyster. The National Research Council (NRC) provided a comprehensive discussion of laws, regulations, and policies governing intentional introductions of nonnative species in the United States (NRC 2004). The following summary is drawn from the NRC's discussion.

Both Virginia and Maryland have enacted statutes restricting importation, possession, and release of nonnative aquatic species to those deemed to be acceptable for introduction into State waters. Virginia law prohibits the importation of shellfish unless they are on a list of approved species (i.e., a "clean list"), or the importer has received written permission from VMRC (VA Code Ann. §28.2-85). The Suminoe oyster is not included on Virginia's clean list; however, in 2002, the Virginia legislature passed a non-binding resolution supporting the introduction of the Suminoe oyster (Virginia House Joint Resolution No. 164). Maryland law gives DNR the authority to prohibit the importation, possession, or introduction into State waters of a nonnative aquatic organism (Natural Resources, §4-205.1, Annotated Code of Maryland). The regulation states that a person may not import or possess shellfish taken from waters outside of Maryland for planting in Maryland waters without a permit issued by DNR (Code of Maryland Regulations 08.02.08.01). DNR will issue a permit only if proof is presented that the shellfish will not be harmful to Maryland shellfish (Code of Maryland Regulations 08.02.08.01). DNR may not introduce nonnative oysters into Maryland waters or issue a permit for an introduction to another person unless biosecurity protocols defined by the International Council for the Exploration of the Sea (ICES) and the recommendations of the NRC (2004) are followed (Natural Resources Article, §4-1008, Annotated Code of Maryland). This PEIS will provide information to assist the authorized management agencies in each state to determine if the Suminoe oyster is acceptable for introduction into the waters of their states.

The Lacey Act of 1900, as amended (16 U.S.C. 667 et seq.; 18 U.S.C. 42 et seq.), which is administered by FWS and NOAA, prohibits importation and interstate transportation of species that are listed as "injurious to human beings, to the interests of agriculture, horticulture, forestry, or to the wildlife or the wildlife resources of the United States." To date, the Suminoe oyster is not listed as an injurious species. A regulation issued under the act (50 CFR §16.13 a 1) bans the release "into the wild" of live or dead "fish, mollusks, crustaceans, or any progeny or eggs thereof" except "by the State wildlife conservation agency having jurisdiction over the area or by persons having prior written permission from such agency." Given that the Suminoe oyster is not listed or proposed for listing as an injurious species under the Lacey Act, this regulation affords DNR and VMRC the authority to permit the establishment of a self-sustaining population of the Suminoe oyster in the Chesapeake Bay, if those agencies deem the species acceptable for introduction into waters in their states.

Executive Order 13112, Invasive Species, issued by President Clinton on February 8, 1999 (64 FR 6183), instructs Federal agencies not to "authorize, fund, or carry out actions that they believe are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless…the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species, and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions." The order defines invasive species as alien species whose introduction is likely to harm the economy, the environment, or human health. The order establishes the National Invasive Species Council (NISC), an interdepartmental organization comprising the secretaries and administrators of 13 Federal departments and agencies whose mission is to lead Federal agencies to develop a comprehensive response to issues concerning invasive species. Neither Executive Order 13112 nor any existing legislation establishes a requirement for Federal regulatory approval to introduce a nonnative shellfish species that is not listed as injurious under the Lacey Act (NRC 2004). Legislation is currently being drafted for presentation to Congress within the next year that, if enacted, would invest NOAA, FWS, or both with such regulatory authority (R. Orr, NISC, pers. comm.). Given that Federal regulatory authority governing some of the alternatives being considered in this Draft PEIS may be established within the time frame for implementing them, it seems prudent to review the NISC's efforts to date.

The NISC issued the National Invasive Species Management Plan (NIMP) outlining several responsibilities of Federal agencies and action items for the NISC (NISC 2001, 2005) that may be relevant to the proposed action and alternatives being considered in this PEIS, if the Suminoe oyster is determined to be an invasive species as defined by the Executive Order. Chief among the relevant components of the NIMP are the NISC's intentions (1) to draft guidance for Federal agencies on addressing the prevention and control of invasive species in the context of NEPA, and (2) to develop a risk-based screening process for evaluating the potential invasiveness of nonnative species proposed for intentional introduction. NISC drafted the NEPA guidance (NISC 2005), and the CEQ is reviewing it (L. Williams, NISC, pers. comm.). NISC created a joint committee with the Aquatic Nuisance Species Task Force to develop the risk-based screening process. A subgroup of that committee, the Aquatic Species Screening Working Group, held a workshop in February 2005 (NISC 2005); however, there is no evidence of a published product of that workshop.

The NISC formed a non-Federal Invasive Species Advisory Council (ISAC) to provide advice and recommendations about issues related to invasive species. The ISAC currently comprises 28 representatives of State governments, private industries, tribes, academia, conservation organizations, and other stakeholders. Although the ISAC includes representatives of several organizations that may have an interest in oysters (i.e., Taylor Shellfish Farms, New York Sea Grant Program, Florida Department of Environmental Protection), no organizations likely to be thoroughly familiar with the proposed introduction of the Suminoe oyster in Chesapeake Bay are represented. The ISAC recently produced a white paper recommending clarifications of the definition of the term invasive species. In it, the ISAC acknowledges that many nonnative species are not invasive and "support human livelihoods or a preferred quality of life" (ISAC 2006). The ISAC (2006) further maintains that determinations of invasiveness must have a biogeographical component because a nonnative species may be considered invasive in one place where it displaces native species or harms the local economy, while the same species is not considered invasive in other places where its beneficial effects are perceived to outweigh its adverse effects. This PEIS will provide information to assist resources managers to determine if the Suminoe oyster should be considered an invasive species in Chesapeake Bay.

1.2 HISTORY OF OYSTERS IN CHESAPEAKE BAY

The Eastern oyster *(Crassostrea virginica*) was once so abundant in Chesapeake Bay that it inspired the Algonquin to name the bay *Chesepiook*, meaning "great shellfish bay." The abundant oyster was a keystone species that provided a variety of ecological services within the Chesapeake Bay ecosystem. It was a primary component of the Bay's filtration system and provided rich habitat for many other species (Newell 1988). Oysters filter water to feed on small plankton, removing sediment and other particles from the water column, clearing the water, and increasing light penetration. Improved water clarity promotes the growth of underwater grasses, which benefit blue crabs and many other aquatic organisms. Oyster reefs also provide a unique kind of habitat for fish and other species in the Bay. In addition to its ecological functions, the Eastern oyster was as an important food resource for Native Americans and early European settlers, and the Bay's oyster fishery developed into a large export industry during the 1800s. The Chesapeake oyster fishery became the largest in the world during the 1880s (NRC 2004). Towns such as Crisfield on Maryland's Eastern Shore were established and prospered solely on the basis of the abundance of oysters in local waters. The oyster became widely recognized as an important cultural symbol of the Chesapeake Bay region.

Commercial landings of oysters in Chesapeake Bay declined steadily during the late 19th and early 20th centuries (Figure 1-1).[3] Harvest yields declined by half in the 50 years between the late 1880s and about 1930. Major factors believed to have contributed to that decline include intense fishing pressure, mechanical destruction of habitat, siltation of optimal substrate, and stock overfishing[4] (Rothschild et al. 1994). The rate of harvest of oysters increased rapidly during the 1800s as watermen began to fish more efficiently by using sailboats (the iconic "skipjack") to dredge oyster reefs instead of the traditional hand-tong method. The use of increasingly destructive harvesting methods increased after 1865, when the use of large mechanized dredges was legalized (Stevenson 1894). Dredging for oysters began to degrade the physical integrity of centuries-old reefs (DeAlteris 1988) by breaking off shell and oysters that were too small to harvest, thereby reducing the population and the habitat available for future production and harvest. By the late 1800s, the historic reefs were severely degraded. One hundred years of increasingly intensive and mechanized fishing contributed to leveling the profile of the oyster bars in Chesapeake Bay (Rothschild et al. 1994). Declining water quality also contributed to reducing the oyster population. Clearing of forests and development of land within the Bay's watershed caused increased agricultural runoff, sedimentation, nutrient input, and environmental pollution that killed oysters or created conditions that were less favorable for them (Kemp et al. 2005; Boynton et al. 1995).

During the mid-20th century, oyster harvests remained comparatively stable for several decades (through the late 1970s) before beginning another steep decline that continues to the present. The Bay's oyster population is now estimated to be less than 1% of its size during the 1800s (Newell 1988). The more recent decline in the population has been attributed primarily to the introduction of two foreign diseases to which the Eastern oyster had no resistance. The diseases Dermo and MSX are harmless to humans but usually are fatal to Eastern oysters. The diseases are caused by protozoan parasites that were first found in the Bay in 1949 (Dermo) and 1959 (MSX).

Dermo is caused by a parasitic, single-celled organism called *Perkinsus marinus*, which is found along the Atlantic and Gulf coasts of the Unites States (Ford and Tripp 1996) and is distributed throughout the water column. Oysters contract Dermo as they filter the water for food. Infected Eastern oysters may transmit the parasite directly to nearby oysters or spread the infection by releasing parasites into the water after death (NRC 2004). Dermo weakens the muscle that opens and closes the shell when oysters feed (Mackin 1962; Gauthier et al. 1990); consequently, infected oysters eventually die from starvation (Choi et al. 1989; Ford and Tripp 1996). Most mortality occurs two to three years after oysters become infected with Dermo.

[3] The size of the oyster population in the Bay has never been monitored regularly. In the absence of reliable estimates of the population, changes in the size of the oyster harvest over time have been considered to be indicative of changes in the abundance of oysters in the Bay. Changes in harvest, however, provide only a gross indication of changing abundance because harvest varies with the level of fishing activity as well as with the population of oysters.

[4] The term "stock overfishing" refers to a level of fishing intensity at which the magnitude of harvest results in a reduction in the reproductive capacity of the stock.

Older, larger oysters generally have the greatest levels of infection because their greater rates of filtration increase their uptake of the parasite from the water column (Andrews and Hewatt 1957).

Water temperature and salinity determine the spread of Dermo. The parasite is active during the warmer months (at temperatures above 20°C) but can survive much colder temperatures (Andrews 1996; Chu and La Peyre 1993). Cool water temperatures during winter and early spring suppress Dermo infections (Andrews 1996; Ragone-Calvo and Burreson 1994). A recent trend toward warmer winters has allowed Dermo to flourish in the Bay (NRC 2004). Dermo is relatively inactive at salinities less than 8 parts per thousand (ppt; Mackin 1956; Ragone and Burreson 1993; Chu et al. 1993), and infection rates decrease during wet years, when a larger-than-average volume of freshwater runoff reduces salinity in the Bay. During the 1980s, several particularly dry years caused salinity to increase in upstream areas of the Bay, where freshwater runoff typically keeps salinity low. These conditions allowed Dermo to spread to many upstream oyster bars that previously had been unaffected (NRC 2004). Transplanting large quantities of diseased seed oysters also is thought to have carried parasites into regions they might not have reached via natural vectors of transmission (Paynter 1999; Wesson et al.1999). "Seed oyster" refers to juvenile oysters or spat from hatcheries or natural sources that are planted on bars where they are expected to grow to market size and, ultimately, to be harvested. Spat generally are most abundant in high-salinity areas where oyster spawning is most successful; therefore, high-salinity areas serve as the primary wild sources of seed oysters. Dermo and MSX, however, are most prevalent in those high-salinity areas. Burreson and Ragone-Calvo (1996) documented the transfer of seed oysters infected with Dermo from an area in the James River, which the parasite had reached naturally, to tributaries of the Potomac River (i.e., Coan and Yeocomico rivers and Machodoc Creek), where Dermo had not occurred previously.

Surveys conducted throughout the Bay from 1990 through 2004 revealed that the prevalence of Dermo ranged from 50% to 95% each year; most years with prevalence greater than 85% were classified as dry (Carnegie and Burreson 2005; Tarnowski 2003; M. Tarnowski, DNR, pers. comm.). The mean annual mortality rates of market-size oysters throughout the Bay from 1991 through 2004 have been estimated to range from 5% to 90% depending on salinity and the prevalence and intensity of disease (Vølstad et al. 2008). These mortalities, however, could have resulted from the effects of both Dermo and MSX.

Oyster Disease Terms

Prevalence – A measure of the frequency of occurrence of infection; the percent of examined oysters that contain at least one disease-causing parasite.

Intensity – A measure of the concentration of parasites within an oyster; high disease intensity generally results in mortality.

Resistance – An oyster either is not susceptible to disease or is subject to only limited infection.

MSX is believed to have been introduced into the Bay through an illegal planting of the nonnative Pacific oyster, *C. gigas* (Burreson and Ragone-Calvo 1996). MSX is caused by a single-celled, infectious parasite called *Haplosporidium nelsoni*, which is now found along the entire Atlantic coast of the United States (Ford and Tripp 1996). Infections of MSX start in an oyster's gill and enter its bloodstream, causing tissue damage and difficulty with respiration and feeding. A large concentration of parasites develops in infected oyster tissue and disrupts the oyster's physical functions, eventually causing death (Ford and Tripp 1996). Eastern oysters infected with MSX produce fewer eggs and sperm than uninfected oysters (Ford and Figueras 1988). The parasite forms spores that are transmitted to new host oysters, but the method of transmission is unknown, and new infections are unrelated to the proximity of infected oysters (NRC 2004).

The prevalence of MSX is controlled by water temperature and salinity, similarly to Dermo. Initial MSX infection generally occurs at water temperatures greater than 20°C and salinities greater than 10 ppt (Ford and Haskin 1982). Oysters may be able to expel MSX parasites if the oysters are exposed to lower salinities for extended periods (Ford and Haskin 1988). Infections generally occur from mid-May to October and kill the host oysters more quickly than Dermo. Oysters infected early in the season generally die between July and October, but oysters infected later in the summer may survive through the winter and die during the following spring (Ford and Tripp 1996). Climatic conditions that cause high salinity and warmer water temperatures during the winter favor the spread of MSX, as they do for Dermo. Infection with MSX was less prevalent than Dermo infection in the Chesapeake Bay between 1990 and 2004. Surveys conducted throughout the Bay revealed that about 1% to 30% of sampled oysters were infected with MSX each year (Carnegie and Burreson 2005; Tarnowski 2003; M. Tarnowski, DNR, pers. comm.). High rates of MSX infection were correlated with dry years, although the statistical relationship was less strong than that observed for Dermo. Both Dermo and MSX became more widespread in Maryland portions of the Bay and in upstream tributaries in Virginia in recent decades, in part because several dry years caused salinity to increase in areas where it previously had been low (Burreson and Andrews 1988; Andrews 1996) and also because of the seed transplanting programs described earlier.

These two diseases have been particularly detrimental to the oyster fishery because they kill many oysters before they reach market size. In the absence of MSX and Dermo, the average lifespan of the Eastern oyster is 6 to 8 years, and the maximum is probably 25 years (NRC 2004). Eastern oysters are marketed in the United States when they reach three inches or more, typically after three to four years in Chesapeake Bay (NRC 2004). Oysters infected with Dermo, however, generally live only two or three years, and oysters infected with MSX generally die within one year. High mortality rates caused by these diseases not only remove oysters potentially available for harvest, but also reduce the number of large, highly reproductive oysters that are left to propagate. Overall, oyster populations in the Bay are now strongly controlled by disease pressure (Ford and Tripp 1996) in addition to being negatively affected by harvest, degraded oyster habitat, poor water quality, and complex interactions among these factors (Hargis 1994; NRC 2004).

1.3 HISTORY OF MANAGEMENT AND RESTORATION EFFORTS

Maryland and Virginia historically have managed oysters in their respective portions of the Bay separately, using a combination of harvest restrictions, size limits, habitat enhancement, and planting of seed oysters to support the oyster fishery. Management efforts during the period from 1930 to 1960 are believed to have helped maintain oyster harvests in the range of 30 to 40 million pounds per year (equivalent to 4.3 to 5.7 million bushels per year) over that time period. These and other management strategies resulted in relatively stable annual oyster harvests in Maryland from the mid 1960s through the early 1980s, while landings in Virginia decreased gradually over the same period (Figure 1-1). Virginia's oyster fishery was affected disproportionately by MSX and Dermo because both diseases are more active in the salty water of the southern portion of the Bay (NRC 2004). About two-thirds of Virginia's oyster harvest over the past several decades was supported by private investment on leased grounds. These investors gradually stopped maintaining their grounds and moving seed because it was not profitable; nevertheless, the State continued its original level of habitat enhancement (J. Wesson, VMRC, pers. comm.). Nearly all the management programs during this time period were aimed at maintaining oyster fisheries, with limited focus on restoring the ecological role of oysters and oyster reefs in the Bay.

The importance of the ecological role of the Eastern oyster within the Bay's ecosystem (i.e., maintaining and improving water quality and creating habitat) gained increased attention as a result of the precipitous decline of the oyster population during the 1980s. State and Federal agencies increasingly began working together to restore oysters. The CBP began in 1983 with the goal of restoring the Bay to its former health and productivity using an ecosystem management strategy. The signatory members of the program were Maryland, Pennsylvania, Virginia, the District of Columbia, and EPA, but many other agencies and stakeholders have joined the effort (http://www.chesapeakebay.net/). The Bay Program identified oyster restoration as a key component for improving the health of the Bay and established specific management goals in its 1987, 1994, and 2000 agreements. The most recent agreement, known as *Chesapeake 2000*, established the goal of attaining a standing oyster population that is 10 times greater than the 1994 baseline by the year 2010. The Chesapeake Bay Executive Council adopted the Chesapeake Bay Oyster Management Plan (OMP) in January 2005 to provide a general framework and specific guidance for restoring and managing the Bay's native oyster resource.

The following sections of this document provide overviews of the most recent major management programs.

1.3.1 Repletion Programs

Repletion programs are designed to take advantage of the life history characteristics of oysters. Oysters have two primary life stages: a planktonic larval stage that is present in the water column and an immobile stage that encompasses the juvenile and adult forms. Oysters reproduce by simultaneously releasing sperm and eggs into the water, where fertilization takes place. Fertilized eggs develop larval characteristics within about 24 hours and are dispersed through the water by currents and, to a lesser extent, by their own swimming ability. Larvae must adhere (set) to a clean hard substrate after two to three weeks in the water column or they will die. Larvae prefer to set on oyster shell (Luckenbach et al. 2005a) but will set on other materials such as concrete and stone. Settled larvae quickly metamorphose into the young-oyster growth stage (spat) and remain immobile for the rest of their lives. Oysters produce very large numbers of gametes (eggs and sperm), and large females can produce many millions of eggs. Because of their great reproductive potential, even small numbers of oysters can quickly increase into large populations when conditions favor settlement and survival of newly set oysters. This trait allows oysters to persist in dynamic environments such as Chesapeake Bay by occasionally producing very large year classes. Such large year classes can compensate for poor year classes that result from unfavorable environmental conditions during other years. Many species of oysters, including Eastern oysters, tend to settle on existing groups of shells called reefs, bars, or beds. The term “repletion” describes two approaches for encouraging settlement, growth, and survival of oysters by planting shell: (1) permanent plantings, in which shell is planted in areas where large spat sets occur naturally, and the resulting spat are left in place until they are large enough to be harvested; and (2) seed-area plantings, in which shell is planted in areas of high salinity where large spat sets are most likely, and the resulting spat are moved to areas of lower salinity to attempt to protect them from disease.

In Maryland, shell for permanent planting historically was obtained by dredging deposits of old, buried shell. The oyster-shell dredging and planting program in Maryland began in 1960. Using an industrial-scale hydraulic dredge, shells were recovered from deposits buried as much as 40 feet deep in the bottom at locations primarily in the upper Bay. Dredged shells were washed and transported to productive oyster bars, where they were planted to create a layer of shell 3 to 6 inches thick. About five million bushels per year were planted until 1990. Beginning in 1991, the program was reduced to about 1.5 to 2.8 million bushels per year. About 350 acres were planted with shell per year (depending on the volume of shell dredged) while the program was in full operation. Some stakeholders have opposed shell dredging because it alters the bottom substrate, may adversely affect other fisheries, and creates a sediment plume. The shell-dredging program ceased in 2006 (DNR 2006).

DNR has investigated alternative means of enhancing substrates suitable for oysters. One alternative is shell reclamation. This involves retrieving previously planted shell that has been reburied due to siltation. The program, which is currently in the developmental design phase, is expected to consist of dredging silted shell plantings to a depth of approximately one foot, stockpiling the shells on a barge or other vessel, and replanting the cleaned shells on a more viable bar nearby. No estimate of the cost of implementing this program for rehabilitating oyster habitat is available currently, but the cost is expected to be comparable with that of the previous shell-dredging program in the upper Bay, which ranged from $5,000 to $8,000 per acre depending on the volume of shell obtained. If implemented, this program could facilitate the rehabilitation of significant amounts of oyster-bar habitat (DNR 2006). DNR also has experimented with using other substrates to create artificial reefs for oysters. Since 2002, DNR has planted approximately 71 acres with the equivalent of 985,000 bushels of alternative habitat materials at a cost of $1.7 million, or $24,000 per acre. The use of non-shell substrates has several limitations. Most of the materials acquire low spat sets and are expensive; furthermore, the available volume of some materials is too small to support a large-scale program for rehabilitating oyster habitat. DNR will evaluate the continued use of alternative materials for restoring oyster habitat in the context of its costs and benefits compared to those of other methods for restoring habitat, such as reclaiming previously planted shell.

In Virginia, oyster shell was dredged for substrate consistently until sometime during the 1980s. The State used only dredged shell at that time because no fresh shell (from shucking houses) was available from the oyster processing industry. After the 1980s, additions of dredged or fresh shell became more sporadic, but more fresh shell was deployed. Between 2000 and 2005, the amount of shell habitat created in Virginia ranged from 35 acres to 142 acres for sanctuaries and from 154 acres to 478 acres for harvest areas (Section 1.3.2). Before 2000, nearly all the shell was placed in harvest areas (J. Wesson, VMRC, pers. comm.).

The concept for seed-area plantings, the second and most common kind of repletion program in Maryland, arose from observations that spat set is greatest on clean oyster shell in highly saline waters and that mortality due to disease is lowest in less salty waters. Each year, clean shell is planted in areas of high salinity, where large spat sets are most likely. Drifting and swimming larval oysters settle on the clean shell and grow into spat. The shell, now covered with tiny oyster spat called seed, is then moved (if seed numbers are large enough) to areas of low salinity to protect the oysters from disease as they grow to harvestable size (C. Judy, DNR, pers. comm.). Shell with seed-counts of less than about 500 spat per bushel generally is not moved because the costs of production and transportation reduce the cost effectiveness of the effort to grow market-size oysters from low seed counts. Much of Virginia's oyster harvest is from natural spat set on privately leased bottom. Although Virginia also has an active repletion program, very few areas in Virginia waters have salinity low enough to protect seed oysters from disease, and many seed-planting efforts have failed because of disease (J. Wesson, VMRC, pers. comm.).

Survival in repletion areas is strongly influenced by the amount of freshwater inflow to the Bay each year. Seed-area plantings produce more market-size oysters during periods when salinity declines due to heavy rainfall than when salinity increases due to drought. Although repletion programs enhance oyster production under some circumstances, they have neither altered disease effects nor contributed significantly to increasing the size of the Bay-wide stock of Eastern oysters because planted seed oysters and any wild larvae that settle on planted shell are subject to harvest when they reach legal size and because the reproductive success of the remaining oysters is low in low-salinity waters. Transplanted seed can carry Dermo or MSX if it is obtained from areas where the disease-causing organisms are prevalent; consequently, repletion programs are believed to have contributed to spreading the diseases (Section 1.2). Maryland's oyster repletion program has supported a large portion of the commercial harvest in the state during the past 10 years. An estimated 80% of the oyster harvest from public grounds in recent years was taken from areas that DNR planted with clean shell or seeded shell (NRC 2004). Shell-planting and seed-planting sites are rotated so that new acreage can be rehabilitated cyclically, and year classes sometimes can be separated. DNR consults with oyster committees for each county annually in March to coordinate shell-planting sites and seed-planting sites with local oystermen. DNR and the committees concur on the selections of bars and sites within bars. The rapidly declining availability of clean shell (Section 1.3.4) is a significant issue that has constrained the extent of Maryland's repletion program in recent years (C. Judy, DNR, pers. comm.).

An additional approach for increasing the amount of suitable habitat for oyster settlement and growth that is not currently a major element of either state's repletion programs is to build structures intended to mimic the three-dimensional characteristics of historical oyster reefs. Federal and State agencies and non-profit groups (e.g., Chesapeake Bay Foundation) are funding projects to construct three-dimensional artificial reefs at several locations in the Bay. In contrast to standard habitat rehabilitation that involves placing relatively thin layers of clean shell on existing hard bottom (i.e., repletion), constructing three-dimensional reefs involves placing thick layers or piles of shell to create bars that are elevated from the bottom of the Bay or installing other hard structures that create elevated surfaces (e.g., large concrete construction debris, specialized artificial-reef structures such as reef balls). Constructed reefs of this nature are designed to counteract the adverse effects of habitat loss due to sedimentation and can elevate oysters above the sediment surface to a height at which the availability of dissolved oxygen (DO) and food may be greater than it is nearer the bottom. VMRC and partners have placed more than 70, three-dimensional reef structures in the Bay since 1993. VMRC has attempted to create new habitat in both subtidal and intertidal areas (intertidal reefs may protrude above the surface of the water at low tide). Although oysters grew rapidly on the structures, most were overcome by disease within two to four years (Mann et al. 2001).

Virginia deployed a prototype, concrete, modular, subtidal reef in the lower Rappahannock River in 2000. Sampling after four and a half years showed four year classes of Eastern oysters on the structure. Approximately half of the oysters were more than two years old (i.e., were old enough to reproduce; Lipcius and Burke 2006), thus creating the potential for increased oyster reproduction, at least locally on that reef. The USACE has created the largest network of sanctuary reefs in the Bay in the Great Wicomico River. Low-relief reefs (LRRs) total 54.8 acres; medium-relief reefs (MRRs), on which the shell surface is elevated above the bottom, total 29.8 acres. Sampling of the constructed reefs has shown positive results, including an increase in the local oyster population by a factor of 62, multiple age classes of oysters, some strong recruitment, and both vertical and cohesive growth of the reefs. Oysters on the MRRs are growing significantly faster than those on the LRRs, and this more rapid growth is contributing to an increase of total shell on the MRRs. These reefs, however, are still "young," and significant mortality due to disease is expected in the future (C. Seltzer, USACE, pers. comm.). Although these findings suggest potential short-term benefits of elevated reefs, the consistency and sustainability of such results over time cannot be predicted.

Southworth et al. (2008) evaluated the performance of 24 constructed, three-dimensional reefs (typically of oyster shell) from the time of their construction in Virginia portions of Chesapeake Bay through 2007, focusing primarily on the intensity of recruitment after construction. Their major findings were as follows:

- An exponential-decay model[5] described spat abundance over time for each reef; none of the reefs examined showed an increase in oyster population (density) over time (longest period was 13 years).
- The largest recruitment tended to occur within the first few years after construction.
- One year-class can dominate reef demographics (regardless of reef age), but this scenario rarely occurs (1/13 yrs), is not sustained, and tends to occur in large watersheds.
- Adding brood stock to reefs does not significantly alter these patterns.

Cost is a major consideration in construction of three-dimensional reefs. Estimated costs for standard habitat rehabilitation range from about $6,436 per acre in Maryland to about $2,249

[5] An exponential decay model is a mathematical formula that characterizes data that show a rapid decline over time.

per acre in Virginia and Potomac River (D. Lipton, UMD, pers. comm.). In contrast, the cost per acre for three-dimensional reefs constructed in Virginia has ranged from about $100,000 to $150,000 per acre (J. Wesson, VMRC, pers. comm.). The USACE, Norfolk District, has abandoned the three-dimensional reef design used by VMRC and is now building reefs in various configurations that result in more height off the bottom than standard replenishment programs, presumably at lower cost (D. Shulte, USACE, pers. comm.).

Oysters occupying three dimensional reefs cannot be harvested using most common harvest methods without damaging the reefs. Such reefs, therefore, are most useful for restoring oysters to provide ecological services. If constructed, three-dimensional reefs were to result in the establishment of local populations of oysters that reach sexual maturity, such structures could serve as a source of oyster larvae that could disperse more widely in the Bay and support harvest on exploitable bars. Neither Maryland nor Virginia has implemented a large-scale program to construct three-dimensional reefs as major elements of their oyster restoration programs to date. Mann and Powell (2007) suggested that the localized benefits of such constructed reefs to a Bay-wide oyster population are not likely to be sufficient to counteract the effect of the loss of hard-bottom habitat throughout the Bay.

1.3.2 Sanctuary and Harvest Reserve Programs

Maryland's and Virginia's most recent management efforts have focused on restoring the ecological benefits of oysters by establishing areas where harvest is prohibited or delayed. Virginia's oyster management plans have included designating oyster sanctuaries where harvest is prohibited, creating artificial reefs to increase habitat available for oysters, and imposing harvest limits. Virginia historically relied on natural spat set in highly saline waters to populate its sanctuaries. Recently, Virginia also has planted hatchery-raised oysters bred for disease resistance in its management programs.

Areas in Maryland set aside for restoration include both sanctuaries and harvest reserves. Sanctuaries are closed to harvest indefinitely by law and regulation. Reserves are stocked and closed to harvest long enough to allow a predetermined percentage of the oysters to grow to market size. Once this objective is achieved, reserves are opened to harvest. Reserves are designed to allow the reefs to provide ecosystem services for some period of time before the surviving oysters are harvested. Sanctuaries and reserves in Maryland are usually seeded with disease-free oyster spat-on-shell[6] produced in oyster hatcheries rather than using natural seed transplanted from seed-areas in the lower Bay, which typically are infected. Sanctuary reefs in Maryland are constructed in subtidal areas by planting shell or alternative materials (i.e., concrete, stone, slag) at a thickness of four to eight inches. Smith et al. (2005) showed that oyster substrate created as part of restoration programs becomes covered with sediment after an average of five and a half years, limiting its long-term benefit. In general, sanctuary programs have established some successful reefs but have contributed a relatively small number of oysters to the total population of the Bay. Their contribution also appears to have been limited by illegal harvesting in some areas that are supposed to be closed to harvest by regulation.

[6] "Spat-on-shell" refers to hatchery-reared oyster larvae that are allowed to settle in groups on pieces of shell in the hatchery. The oyster-covered shell is then transplanted to the areas for planting.

1.3.3 Funding for Oyster Restoration

Funds contributed by the States and the Federal government to support in-water restoration of the native oyster population and recovery of the fishery throughout Chesapeake Bay totaled approximately $17 million for sanctuaries and $41 million for harvest areas from 1994 through 2006 (Figure 1-2). The annual production of hatchery-raised oyster seed increased from 38 million in 2000, to 350 million in 2006. The hatchery-raised seed oysters have been distributed to managed reserves, harvest grounds, and sanctuaries to "jumpstart" recovery efforts in Chesapeake Bay. Oyster restoration partners prepared and/or seeded nearly 600 acres of suitable bottom habitat in Chesapeake Bay. In 2006, the USACE planted shell on approximately 51 acres in the Chester, Choptank, and Severn rivers and continued seeding reefs in the Great Wicomico River (DNR 2007).

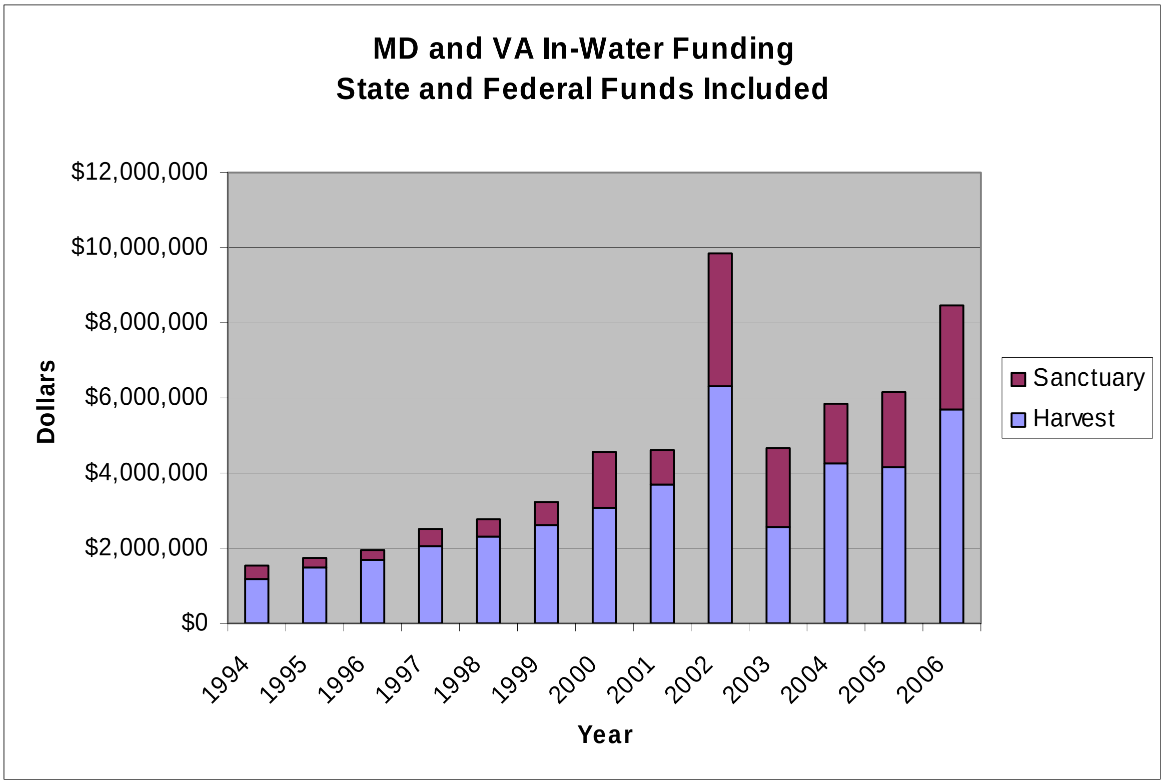

Figure 1-2. State and Federal funding for oyster sanctuary and harvest programs in Maryland and Virginia from 1994 through 2006; figures include the States' expenditures as well as Federal funds from the USACE, EPA, and NOAA; data compiled by DNR.

1.3.4 Constraints on Restoration Programs

Funding clearly is a potential constraint on the continuation or expansion of oyster restoration programs. As shown in Figure 1-2, concern about the status of the oyster in Chesapeake Bay at both local and national levels resulted in a nearly five-fold increase in funding between 1994 and 2006. Regardless of funding, limited availability of hatchery capacity for producing seed oysters and substrate material for increasing oyster habitat could limit the future scope of restoration programs. Existing hatchery capacity in the Bay was considered in defining the restoration strategies evaluated in this Draft PEIS (Section 2). Expanding existing hatcheries or constructing new ones to supply enhanced restoration efforts would require increased funding. One alternative to increasing hatchery capacity would be to purchase Eastern oyster spat from hatcheries outside the Bay area. Meeting the demand for habitat enhancement material is more problematic.

The current high rate of loss of oyster habitat combined with the disappearance of sources of shell for enhancing habitat are generally recognized as major obstacles to all oyster restoration efforts. A sampling of 18 oyster bars considered to be representative of oyster habitat in Maryland's portion of the Bay revealed a 70% loss of suitable oyster habitat on those bars between about 1980 and 2000, suggesting a 3.5% loss of oyster habitat each year (Smith et al. 2005; Attachment 1 of Appendix A). Sedimentation and the deterioration of existing shell both contribute to this loss. Mann (2007a) found that that 20% or more of the shell stock in the James River is lost each year as a result of natural processes. The high rate of habitat loss is a critical issue for the future of oyster populations because larval oysters require hard substrate on which to settle. A healthy, growing oyster population creates its own habitat through production of new shell. At their current low level of abundance in the Bay, oysters are not creating adequate amounts of new shell to support a significant increase in the population. The two sources of shell available for habitat restoration in the past were shucking houses and buried shell deposits dredged from the bottom of the Bay. These sources have waned or ceased to exist completely, resulting in a significant shortage of new shell for oyster restoration programs. Continuing habitat degradation throughout the Bay decreases whatever potential may exist for reproductive success of the existing remnant oyster stock (Mann and Powell 2008). The limited ability to increase and maintain new areas of clean substrate for larval settlement, therefore, is a major constraint on restoration programs in both states.

The current high rate of loss of oyster habitat combined with the disappearance of sources of shell for enhancing habitat are generally recognized as major obstacles to all oyster restoration efforts.

1.3.5 Outcomes of Management Programs

As implemented to date, the management programs described above have produced no substantial increase in oyster harvests over the past decade. The 10-year average harvest from 1997 to 2006 was 1.3 million pounds (approximately 186,700 bushels) with a standard deviation of 1.1 million. The average from 2002 to 2006 was 0.4 million pounds (approximately 57,100 bushels) with a standard deviation of 0.3 million pounds (D. Lipton, U. of MD, pers. comm.). The decreasing average harvest for the most recent five years clearly illustrates that management efforts have not enhanced harvests. Decreasing oyster harvests generally indicate a decreasing population of market-size oysters (more than 3 inches long). Other factors, however, can contribute to a decrease in harvest (e.g., establishment of oyster reserves and sanctuaries where harvest is limited or prohibited), and harvest figures provide no information about the abundance of young oysters that have not yet reached market size.

As implemented to date, management programs have produced no substantial increase in oyster harvests over the past decade.

Neither Maryland nor Virginia conducts surveys to estimate the size of the oyster populations in their respective portions of the Bay; however, data from several fishery-independent surveys conducted for management purposes provide a means of developing such estimates. These estimates are available at a Web site entitled "Chesapeake Bay Oyster Population Estimates" (http://www.vims.edu/mollusc/cbope/basin.htm). A more recent re-calculation of population estimates for Maryland waters is documented in Attachment 7 of Appendix A to this Draft PEIS. Figure 1-3 presents estimates of Bay-wide oyster biomass for the years 1994 to 2006; data for Virginia are from the Web site noted above, and data for Maryland are from Attachment 7 of Appendix A. The size of the population is estimated in terms of biomass because that measurement allows all ages and sizes of oysters to be counted together and because biomass is a useful measure of the magnitude of ecological services that the population may be contributing.

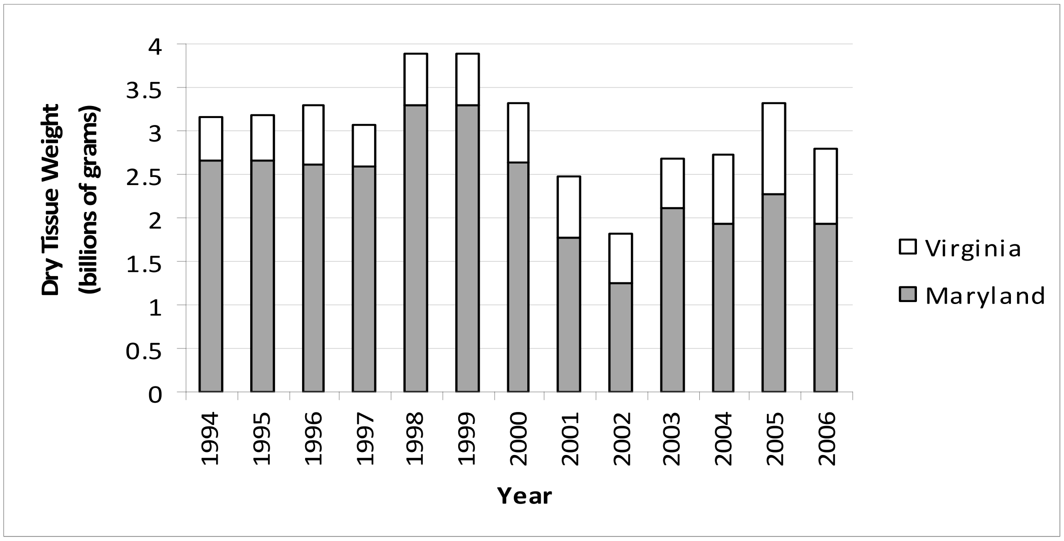

Figure 1-3. Estimated biomass of oysters present in the Maryland and Virginia portions of Chesapeake Bay from 1994 to 2006. Estimates are based on fishery-independent surveys conducted by DNR and the Virginia Institute of Marine Science.

Although the population estimates have a high degree of uncertainty and vary from year to year, a general downward trend in oyster abundance over the most recent decade is apparent. The 2006 total is about 88% of the total for 1994, and the likelihood of attaining the *Chesapeake 2000* goal of a standing oyster population that is 10 times greater than the 1994 baseline by the year 2010 appears small. These data and the harvest data suggest that recent oyster restoration and management programs have not increased the Bay-wide population of oysters and have not enhanced the oyster fishery in the Bay.

> The likelihood of attaining the *Chesapeake 2000* goal of a standing oyster population that is 10 times greater than the 1994 baseline by the year 2010 appears small.

1.4 CONSIDERING THE INTRODUCTION OF A NONNATIVE OYSTER

Recognizing the failure of current management, repletion, and restoration programs to reverse the long-term decline of the Bay-wide oyster population, Maryland and Virginia began to consider nontraditional approaches to rebuilding the oyster stock. Oyster diseases appear to be a significant factor inhibiting the recovery of the stock; therefore, one approach being considered is to introduce a nonnative oyster that has environmental requirements similar to those of the Eastern oyster and might provide similar ecological services but is resistant to MSX and Dermo. Initial investigations during the 1990s focused on the Pacific oyster (*C. gigas*) which is native to Asia and has been cultivated in many estuaries throughout the world (Mann et al. 1991). Pacific oysters can acquire Dermo but tend not to suffer appreciable mortality or growth effects (Barber and Mann 1994; Calvo et al. 2001). Although the Pacific oyster demonstrated resistance to MSX and Dermo in tests in Chesapeake Bay, it was subject to severe mud blistering caused by a native, shell-boring worm called *Polydora*. The effects of *Polydora* rendered most Pacific oysters grown in Chesapeake Bay waters unmarketable and increased their vulnerability to predation by weakening their shells (Calvo et al. 1999).

The Suminoe oyster (*C. ariakensis*), another nonnative oyster from Asia currently being considered for introduction, was first imported to the West Coast of the United States in 1957 to be evaluated for use in aquaculture. No stocks descended from those early imports exist today. The "Oregon stock" of Suminoe oysters originated from a shipment of seed imported from Ariake Bay, Japan, between 1969 and 1971 (Bohn et al. 2004). These seed oysters were grown in a bed with other oysters in Yaquina Bay, Oregon, where a shellfish grower noticed that a few oysters grew unusually quickly. Analyses conducted by what is now the Hatfield Marine Science Center of Oregon State University (OSU) identified the fast-growing specimens to be Suminoe oysters. Researchers from OSU recovered 12 to 15 adult Suminoe oysters from the bed in Yaquina Bay and spawned them in hatcheries. OSU conducted field trials to examine growth rates in Tomales Bay, California (in bags on racks); Mud Bay, Washington (on bottom); Yaquina Bay, Oregon (in rafts); and Coos Bay, Oregon (bottom culture) between 1990 and 1993. The University of Washington conducted field studies on reproduction and gonad maturation in Oakland Bay, Washington (Perdue and Erickson 1984). OSU later transferred the brood stock to commercial hatcheries that frequently held oysters to produce seed for private growers. OSU has tracked the progeny of these founding Suminoe oysters for more than 30 years (Perdue and Erickson 1984; Langdon and Robinson 1996).

Hatchery production of the Suminoe oyster by commercial growers on the West Coast was sporadic and brief due to difficulties with rearing the species and competition with the numerous varieties of oysters available for the niche markets at which growers were targeting the Suminoe oyster. Although several growers obtained Suminoe seed through OSU, the most experienced was Louis Wachsmuth, the founder of the Oregon Oyster Company (OOC) and the grower on whose beds the initial Suminoe oysters were discovered. Mr. Wachsmuth experimented with cultivating the Suminoe oyster on the bottom and in floating cages. The OOC maintained 80 to 100 acres of commercial Suminoe oyster beds for an extended period of time. In a presentation to the Pacific Coast Oyster Grower's Association in 1979, Mr. Wachsmuth ranked the Suminoe oyster the highest among seven species for several commercial traits. Other growers that produced Suminoe seed included the Bay Center Oyster Company in Bay Center, Washington; the Lummi Indian Nation in Bellingham, Washington; and the Whisky Creek Shellfish Hatchery in Netarts, Oregon. The brood stock maintained by the Lummi Indian Nation eventually was transferred to North Carolina through the Virginia Institute of Marine Science (VIMS).

The brood stock held by Taylor Shellfish Farms at Totten Bay, Oregon, and North Bay, Washington, are the only remaining descendents of the Oregon stock being held on the West Coast. The stock has spawned 5 times in 15 years. The several generations of this stock are free of pathogens and have not experienced any unusual mortality (Bohn et al. 2004). Seed or progeny from the seed of this stock have been used in field and lab studies in Chesapeake Bay and in North Carolina (e.g., Calvo et al. 1999, 2000, 2001; NRC 2004). The founding population of the Chesapeake Bay brood stock of Suminoe oysters being maintained at VIMS and at the Horn Point laboratory in Maryland consisted of 9 males and 7 females that were progeny of the original Oregon stock of 12 to 15 Suminoe oysters whose descendents are now being maintained by the Taylor Shellfish Company (S. Allen, VIMS, pers. comm.). The Oregon stock also provided a source of seed for research projects in France (NRC 2004).

Studies to assess the extent to which the Suminoe oyster might be suited to estuarine environments along the East Coast began in North Carolina in 1996 and in the Chesapeake Bay region in 1998 (Attachment A of Appendix B). Biosecurity measures are employed to avoid unintentionally introducing the species into East Coast estuaries during these studies. Special containment facilities were established at the hatcheries in Maryland and Virginia where the species is housed and propagated. The Suminoe oysters to be deployed for studies in Bay waters are altered to render them almost completely sterile[7] and contained in bags or cages during the studies. These studies have shown that MSX and Dermo typically do not kill Suminoe oysters and that Suminoe oysters generally grow faster than Eastern oysters (details of study findings are presented in Section 4.1.1 and in Appendix B, Section 4.2). These biological attributes have lead proponents of an introduction to believe that the species could become established and prosper in Chesapeake Bay and enhance both the oyster fishery and the ecological services provided by oysters.

Planned and accidental introductions of nonnative species, however, often have had unexpected negative effects on the ecosystems that receive them (Kolar and Lodge 2001); moreover, the introduction of a naturally reproducing nonnative species into an open aquatic environment is almost certainly irreversible (NRC 2004). In response to such concerns, the Chesapeake Bay Commission, the Chesapeake Bay Foundation, EPA, and the U.S. Senate Committee on Appropriations asked the NRC of the National Academy of Sciences to describe the state of knowledge about the Suminoe oyster in order to assess the risks involved with introducing the species into Chesapeake Bay. The NRC's report, *Nonnative Oysters in the Chesapeake Bay* (NRC 2004), identified gaps in the state of knowledge about the Suminoe oyster and recommended research needed to support an adequate risk assessment. An additional review by the Scientific and Technical Advisory Committee (STAC) of the CBP also identified research needs and ranked them according to priority (Breitburg et al. 2004). In 2004, Maryland, Virginia, and the PRFC funded some of the needed research, and NOAA initiated a three-year

[7] A normal, fertile oyster has two sets of chromosomes (i.e., diploid or 2n), but an altered "triploid" oyster has three sets (3n). The presence of a third set of chromosomes generally renders the oyster sterile. See Section 4.1.6 for more information about how triploids are produced.

research program to fill the gaps in research that the NRC and STAC identified has having the highest priority.

This Draft PEIS incorporates the results, to date, of those studies and others that have been or are being conducted to address research needs related to the proposed action to introduce the Suminoe oyster in Chesapeake Bay. Section 2 describes the proposed action and alternatives in detail and provides justification for dismissing two alternatives from further consideration. Section 3 describes the potentially affected natural and human environments defined for this PEIS, and Section 4 describes and evaluates the predicted environmental consequences of the proposed action and six alternatives. The public scoping and consultation components of the NEPA process for this PEIS are described in detail in Section 5.